

AN LDRD SUCCESS STORY



MOVING MASSIVE DATA

National security requires global information superiority by reliably and securely transporting ever-increasing volumes of data at ever-faster rates. The objective of the Secure Air-Optic Transport and Routing Network (SATRN) laser communications project was to enable the U.S. military to eliminate bottlenecks that hinder secure transmissions, reducing the delay between gathering intelligence and the ability to act on it.

How SATRN is BETTER

Livermore's SATRN team has developed several innovative technologies to allow the communication laser beam to cut through the atmosphere, minimize beam fading, and amplify the beam's power to counter atmospheric attenuation, temperature differences, and turbulence.

The SATRN optical testbed was used to demonstrate the longest-ever terrestrial high-capacity air-optics link. Formerly, laser communication could only be used to transmit information very short distances, typically between buildings 100 to 500 meters apart.

Data transmission rates of 100 gigabits per second achieved with SATRN are equivalent to 1.6 million simultaneous phone calls. The fastest transmission rate using state-of-the-art radio-frequency links, by comparison, is slightly over $\frac{1}{4}$ gigabit per second.

High-speed, secure laser communications for the military may have applications in wireless Internet connections, tele-medicine, tele-maintenance, emergency response, and natural disaster prediction and warning.

SATRN: ADVANCED TECHNOLOGY FOR LONG-RANGE LASER COMMUNICATIONS

DEVELOPMENT OF A SECURE TRANSPORT AND ROUTING NETWORK

- The Laboratory Directed Research and Development (LDRD) Program funded SATRN's initial development in 2001. A baseline laser communication system was configured with 10 optical channels combined into a single beam with data rates just under 2.5 gigabits per second over a 1.3-kilometer testbed.
- Early in 2002, the Livermore team completed one of the longest high-capacity laser communication links in history with a system that included a 6-inch transmitter and a 16-inch receiver. A 28-kilometer link transmitted data at 2.5 gigabits per second on a single laser channel.
- In 2003, a world-record 100 gigabits per second of data was transmitted to nearby Mt. Diablo using 40, 2.5-gigabit-per-second channels running at slightly different wavelengths. The setup included a 20- and a 16-inch transceiver.
- A 35-kilometer round-trip, 2.5 gigabit-per-second communications link to an aircraft was also demonstrated in 2003 in collaboration with the Naval Postgraduate School's Center for Interdisciplinary Remotely Piloted Aircraft Studies. A retroreflector to send light back to the source and a "power-in-bucket" detector for maximizing the laser energy from a ground-based 16-inch transceiver were employed.
- In 2005, the first fully autonomous 10-gigabit-per-second duplex ground-to-aircraft link was achieved. In addition, the first round-the-clock autonomous operation of a long-range (28-kilometer) error-free ground link was executed.
- SATRN technologies have resulted in ten patented inventions and three development agreements with industrial partners. The initial LDRD investment of \$4.8 million has yielded over \$35 million in work-for-others efforts to develop high-bandwidth optical communication links for military planners and civilian use.

ABOUT LDRD

The Laboratory Directed Research and Development (LDRD) Program is LLNL's primary mechanism for funding cutting-edge R&D to enhance the Laboratory's scientific vitality. Established by Congress in 1991, LDRD collects funds from sponsored research and competitively awards those funds to high-risk, potentially high-payoff projects aligned with Laboratory missions.



The post-SATRAN airborne laser terminal is shown mounted to the underside of the nose cone of a Naval Postgraduate School Pelican aircraft. The program drew on Laboratory strengths in lasers, optics, and photonics as well as attracting new talent and collaborations.

How SATRN Works

Laser communication consists of an optical system in which information is encoded on laser beam signals, or channels, and transmitted through free space to a receiver telescope that detects and decodes the signal. Air-optic laser communications can connect an assortment of platforms, including planes, ground-based facilities, and ships and can allow large transfers of data in real time. Data from SATRN's horizontal lasercom experimental testbed was used to calibrate performance models and simulations of terrestrial links to airborne intelligence, surveillance, and reconnaissance platforms. The project facilitated the growth of new programs geared toward deployment of novel open-air laser-communication technologies on sponsor platforms.

NEW TECHNOLOGIES MAKE IT POSSIBLE

The SATRN concept incorporates high-power fiber amplification techniques and optimized communication transceiver subcomponents. Although adaptive optics for wavefront control were evaluated in the early part of the program, SATRN researchers subsequently developed novel techniques including patented, custom atmospheric noise-suppression systems and a fade-tolerant forward-error-correction approach that provided sufficient link margin and eliminated the need for adaptive optics subsystems. This dramatically reduced the transceiver system size, complexity, and power consumption, as can be seen in this comparison of the original SATRN transceiver enclosure (rear) and post-SATRAN optical transceiver (foreground).

